Evaluation of Floss Remnants After Implant Flossing in Three Different Implant Conditions: A Preclinical Study

Marco Montevecchi, DDS1/Leoluca Valeriani, RDH1/Lucia Franchi, RDH1/
Nicola Marco Sforza, DDS2/Gabriela Piana, MD, DDS3

Purpose: The aim of this preclinical study was to evaluate whether implant flossing could leave floss residues in three different implant-prosthetic conditions. Materials and Methods: Using an anatomical model, three different conditions were studied: correct connection between the implant and abutment and complete insertion of the implant threads into the plaster (control group); misfit of approximately 220 to 230 μm between the implant platform and abutment in the absence of any thread exposure (misfit group); partial exposure of implant threads but absence of misfit (thread group). Twenty-one microstructured tapered threaded implants were divided among the three groups. Each sample was subjected to a flossing procedure using spongy floss, standardized in terms of movement, frequency, time, and pressure. Subsequently, a stereomicroscope examination with a standardized magnification of 10× was performed in order to highlight the possible presence of floss residues on the implant surface. Results: No floss residue was ever detected for the control group. Both misfit and thread groups showed floss residues that were discernible in two different types: microfilaments and amorphous particles. Statistical analysis showed a significant difference for the presence of floss remnants between the control group and the other two experimental groups ($P = .005$). No difference was observed between the misfit and thread groups. Conclusion: This study shows that exposed threads and misfit can induce the release of floss residues during maintenance procedures. Int J Oral Maxillofac Implants 2021;36:569–573. doi: 10.11607/jomi.8350

Keywords: dental implants, implant flossing, implant maintenance, oral hygiene, spongy floss

The clinical use of dental implants has become highly predictable in recent decades, improving the quality of life in patients by restoring both functional and aesthetic support.1,2

Along with the high reliability, it is important to realize that not all implants that survive are necessarily successful. Successful implants are those that remain fully functional and healthy within the oral cavity.

Peri-implantitis is a pathologic condition associated with implant failure and is becoming rather prevalent. Several studies have shown that patients with poor plaque control and erratic maintenance display an increased risk of developing peri-implantitis.3–5 It is therefore prudent to prevent bacterial colonization by having very accurate oral hygiene. After implant placement, a strict follow-up regimen with a dental professional should be implemented in order to monitor the implant and surrounding teeth for inflammatory disease.6

Dental professionals should continually encourage patients to adhere to consistent home oral care in order to prevent any peri-implant inflammation and in turn increase the success of their implants.7

It is very important to underline that implant rehabilitation implicates new anatomical conditions. The relation among the implant and surrounding tissues, as well as the prosthetic rehabilitation, require specific considerations about hygienic care.

One of the most frequently prescribed hygienic devices for home oral care is dental floss; in particular, the stiffened-end spongy floss is quite commonly used thanks to its adaptability.

Narrow interproximal spaces, tilted structures, and submarginal areas are only some of the anatomical situations where specialists suggest its use.

Very few studies have been published supporting this ordinary prescription, generally mutualized by the dental
care or supported by strictly personal experience. The evidence regarding implant care is indeed still sparse, especially compared with that for natural teeth.

Some authors have recently raised concerns about implant flossing. Cases of trapped floss fibers around implants with clear signs of peri-implant disease have been reported, suggesting a potential role for the clinical manifestation.

The presence of retained floss fibers could favor plaque retention, condition acting like floss ligatures for experimental peri-implantitis in animal studies. On the other side, eventual floss remnants can also induce a direct immune reaction by the host. A condition that potentially correlates with the peri-implantitis theory was described by Albrektsson et al. The authors emphasized the primary role of the immune system imbalance in peri-implant marginal bone loss. In this theory, the dental implant is perceived by the immune system as a foreign body, and consequently, the presence of additional foreign bodies, such as prosthetic cement or eventually floss remnants, can lead to greater bone loss.

Several physical-mechanical aspects have been implicated in this clinical circumstance with implant flossing, such as the incongruous implant-abutment connection, or the implant rough surface exposure.

According to these considerations, the aim of this in vitro study was to evaluate whether the generally recommended use of spongy floss around dental implants could represent a dangerous procedure in unexposed or exposed implant surfaces and in implants with a wrong implant-abutment connection. The null hypothesis was that no difference in remnants in the three implant conditions herein evaluated would be observed; ie, the spongy floss works in the same way.

MATERIALS AND METHODS

In this in vitro pilot study, 21 microstructured tapered threaded implants with an internal trilobate connection (Replace Select Tapered TiUnite, NP 3.5 × 10 mm, Nobel Biocare) were selected. This implant was chosen for its macro characteristics, which can be considered representative of the most commonly used implants.

Implants were equally and randomly divided into three groups. According to the study group in which they were assigned, implants were differently immersed in dental plaster (picodent quadro-rock plus) contained in plastic boxes (6 × 5 × 3 cm).

Seven implants with the corresponding abutments correctly inserted were completely fixed in the plaster, with the exception of the smooth neck (control group; Fig 1a). Seven implants with corresponding abutments positioned to create a small misfit (inadequate adaptation of the abutment on the implant) of approximately 220 to 230 μm, with the limit of the stereomicroscope resolution, were completely fixed in the plaster with the exception of the smooth neck (misfit group; Fig 1b). Seven implants with a correct implant-abutment connection were fixed in the plaster, leaving four threads exposed (thread group; Fig 1c).

Subsequently, the implants of each group were exposed to the cleaning movement of the spongy part of the multifilament floss (Superfloss, Oral-B). In particular, the spongy floss was manually adapted by forming a loop with the crossed ends at the implant-abutment connection or the eventual exposed implant surface. In this position, the circular criss-cross movement was induced by applying a controlled pressure of 150 to 200 N, which was measured with an appropriate stress...
and tension gauge (stress and tension gauge 25 to 250 g, Dentaurum) connected to one end of the floss. Standardized movements were made both in terms of speed, with a cadence dictated by a professional metronome (Taktell small metronome, Wittner), and in number of movements for a total of 10 tractions in a total time of 10 seconds carried out by a single researcher (L.F.). Particular attention was placed during the floss movement in not approaching the plaster.

After this, in order to evaluate the possible presence or absence of floss remnants, an experimental stereomicroscope analysis (with a standard magnification of 10×) was carried out. The stereomicroscope (Carl Zeiss Stemi 2000-C, FL S configuration with KL 1500 electronic) connected to Axiocam MC system was used to collect pictures of eventual remnants of spongy floss fibers on the study samples after the simulated hygiene procedures. The outcome of the study, ie, the floss residues, were dichotomously detected (presence/absence) and described on the basis of their shape. Measurements were performed using specific software (ImageJ1).

**Sample Size**

A pilot sample of three implants reproducing the experimental conditions was used to estimate the noninferiority margin.

At a significance level of $\alpha = .05$ for a one-sided test, at 80% power, a noninferiority margin equal to 40%, and an allocation ratio equal to 1:1, a total sample size of 14 implants was needed (7 in each of the two experimental groups). A control group of 7 implants was also created.

**Statistical Analysis**

Cross tabulations were used to describe the observed results. The chi-square test and Fisher test were performed, aiming to evaluate differences in material presence, respectively, among the three groups and between floss and amorphous floss particles in the two experimental groups. The level of significance $\alpha$ was a priori set at .05.

**RESULTS**

After flossing, all implants were analyzed (Table 1). All dental implants in the control group did not show any floss remnants both on the smooth surface of the neck and next to the implant-abutment connection.

Misfit group implants showed the presence of floss material remnants in 85.7% of cases. In particular, in the misfit space, spongy floss microfilaments were found only in one implant, another implant showed amorphous particles (ranging from 50 to 600 μm), and four implants presented both microfilaments and amorphous particles (Fig 2). Only one implant was free of any spongy floss material.

The thread group showed remnants of spongy floss in 57.1% of the implants. In particular, spongy floss microfilaments were observed in one implant, whereas amorphous particles were present in the other two (Fig 3). Both microfilaments and amorphous particles of spongy floss fibers were observed on one implant. However, no microfilaments or amorphous particles were detectable on exposed surfaces, around the smooth neck, or at the implant-abutment connection of three implants.

---

**Table 1** Presence/Absence Percentage of Spongy Floss Material in the Three Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Presence</th>
<th>Absence</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0 (0.0)</td>
<td>7 (100.0)</td>
<td>7 (100.0)</td>
</tr>
<tr>
<td>Misfit</td>
<td>6 (85.7)</td>
<td>1 (14.3)</td>
<td>7 (100.0)</td>
</tr>
<tr>
<td>Threads</td>
<td>4 (57.1)</td>
<td>3 (42.9)</td>
<td>7 (100.0)</td>
</tr>
</tbody>
</table>

© 2021 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY. NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.
The observed differences with spongy floss remnants (microfilaments and amorphous particles) among the three groups were statistically significant (chi-square test = 10.691, \( P = .005 \)). The null hypothesis was therefore rejected.

No significant difference was found between the samples of the misfit and thread groups (Fisher exact test shows a value of \( P = .2861 \)).

**DISCUSSION**

From the present study, no floss remnants were detected on control group implants.

Therefore, presupposing a potential pathogenicity of these remnants to peri-implant surrounding tissues, the use of spongy floss seems to represent a safe procedure in a “regular state” implant.

However, the spongy floss left residues in 85.7% of the misfit group’s implants and in 57.1% of the thread group.

The misfit in a finalized implant rehabilitation can be due to several conditions, such as mechanical inconsistency and anatomical impediment. In particular, it is represented by the incomplete insertion of the abutment to the implant, as well as the absence of an ideal matching between the abutment and the prosthetic crown.

In order to limit the misfit occurrence, a combination of visual, tactile, and radiographic examinations should be performed.\(^\text{15}\)

The scientific literature on implant-supported fixed dentures reports a wide range of values (from 10 to 160 \( \mu \text{m} \)) to consider the misfit technically acceptable. However, as clearly stated by two recent systematic reviews,\(^\text{15,16}\) it is still lacking the effective role of misfit. It is quite rational to think that, not only the presence of it, but also its dimension can influence the effective ability to trap floss remnants. Further studies focusing on different gap dimensions are consequently strongly recommended.

Thread exposure was the other clinical aspect investigated in this study. Its presence can be a consequence of either paraphysiologic or pathologic conditions. The eventual bone remodeling (following implant placement)\(^\text{17}\) as well as the bone resorption (caused by inflammatory peri-implantitis or foreign body response)\(^\text{14,18}\) are the prevalent conditions.

Irrespective of its origin, thread exposure is also the result of a clinical condition that is able to trap floss remnants. In this specific circumstance, the macrotexture and microtexture of the implant can play a role in the final result. It is therefore rational to suggest future investigations in this field.

In the present work, a clear distinction between two kinds of floss remnants has been made: amorphous particles and microfilaments. This distinction comes from the assumption that the two forms of residues may have different clinical implications. The first consideration is that amorphous particles can be more prone to a spontaneous expulsion in respect to microfilaments. To support this consideration, it is a necessary reminder that all clinical cases up to the date described were characterized by the detection of filamentous remnants.\(^\text{11,12}\) On the other hand, it must be taken into account that this is probably because microfilaments display a more direct and intuitive correlation to the dental floss. Consequently, it is not known which is the real role of these particles, and investigations on this topic are strongly advocated.

In accordance with the manufacturer statements, the spongy floss used for this research is composed by nylon fibers covered by colored and aromatized wax.

Amorphous particles herein detected could probably correspond to wax remnants, and this consideration is supported by the findings of van Velzen et al (2016).\(^\text{12}\) In a preclinical set, the authors analyzed the implant surface after flossing and detected the presence of organic material through spectrophotometry, plausibly wax.

In this study, where the prevalence of microfilament and amorphous particles between the two investigated conditions has been observed, it could be speculated that flossing on exposed threads may tend to release more amorphous residues. Otherwise, sliding floss against misfit may tend to cause tearing and the consequent release of microfilaments. The absence of a statistically supported difference limits any further consideration, but it can be rational to deepen this aspect in further studies on broader samples. Other aspects that advocate for future investigations are the floss typology and the flossing movement.

To the best of the authors’ knowledge, the etiopathogenetic role of these residues has not yet been discovered. However, the presence of trapped floss remnants in the subgingival area may be a fertile environment for bacterial invasion and proliferation. From this consideration, it can be assumed that dental floss residues can promote the retention of bacteria and have an action quite similar to that of experimental ligatures\(^\text{15}\) or biofilm-retaining factor like luting cementum residues.\(^\text{19,20}\)

For the pathogenic hypothesis, the host response to those remnants acting as foreign bodies cannot be neglected. This aspect finds an interesting correlation with the peri-implantitis theory described by Albrektsson et al.\(^\text{14}\)
From the cases reported in the literature, it can be observed that the removal of these residues generally leads to clinical improvements. Van Velzen et al (2016) reported that in the last 3 years of clinical practice, they have encountered 10 patients with persistent peri-implantitis, previously treated with a nonsurgical and surgical protocol for the maintenance of implants (to which all of their patients with peri-implantitis are treated). Among those 10 patients, after exploratory surgery, all implants showed the presence of remnants of dental floss adhering to the rough part of them. Interestingly, after careful removal and debridement of the peri-implant site, 9 of 10 cases resulted in an improvement in peri-implant conditions 6 months later (ie, absence of bleeding on probing and reduction of probing pocket depth).

These results are supported by long-term observations of a clinical case report describing peri-implantitis treated with endoscopic access. Trapped filaments around several implants were thoroughly removed, leading to a complete resolution of the peri-implantitis with a 6-year stable result.

CONCLUSIONS

This preclinical study has clearly demonstrated how implant thread exposure and implant-abutment misfit can both favor the release of remnants from a spongy floss.

ACKNOWLEDGMENTS

The authors thank Dr Maria Rosaria Antonella Gatto (University of Bologna) for statistical assistance. No financial and material support has been received. The authors reported no conflicts of interest related to this study.

REFERENCES